Claim Or Claims

1) An apparatus useful for gas phase analysis of ions comprising:

a. an hourglass electrodynamic funnel formed of at least an entry element, a center element, and an exit element, each of said elements having an aperture, and wherein said entry element is aligned such that a passageway for charged particles is formed through the aperture within said entry element, through the aperture in said center element, and then through the aperture in said exit element, and wherein said aperture in said center element is smaller than the aperture of said entry and said exit elements, and

b. a drift tube, wherein the hourglass electrodynamic funnel forms the entrance to the drift tube thereby providing a passageway for ions generated in a relatively high pressure region at the exterior of the drift tube to a relatively low pressure region at the interior of the drift tube through said elements.

2) The apparatus of claim 1 further comprising a jet disturber placed within said hourglass electrodynamic funnel.

3) The apparatus of claim 1 wherein said apertures have a shape selected from the group consisting of circular, ellipsoidal, and rectangular.

4) The apparatus of claim 1 further comprising a means for temporarily containing the flow of ions out of the aperture of said exit element of said hourglass electrodynamic funnel.

5) The apparatus of claim 4 wherein said means is selected from the group consisting of a plurality of wires, a mesh, and a microchannel plate.

6) The apparatus of claim 1 further comprising a means for intermittently terminating the flow of ions by deflecting them using an electric field orthogonal to the ion path.

7) The apparatus of claim 6 wherein said means is selected from the group consisting of a Bradbury-Nielsen gate, two or more deflection plates, and a split lens.

8) The apparatus of claim 1 further comprising an ion analysis means in communication with an exit to said drift tube, said exit located at the opposite end of said drift tube from said electrodynamic funnel.

9) The apparatus of claim 8 wherein said ion analysis means is selected from the group consisting of a mass spectrometer, a photoelectron spectrometer, and a photodissociation spectrometer.

10) The apparatus of claim 9 wherein said mass spectrometer is selected from the group consisting of a quadrupole mass spectrometer, a time of flight mass spectrometer, and a Fourier-transform ion cyclotron resonance mass spectrometer.

11) The apparatus of claim 1 wherein said drift tube is an ion mobility spectrometer.

12) The apparatus of claim 1 wherein said drift tube is selected from the group consisting of a field asymmetric waveform ion mobility spectrometer, a selected ion flow tube, and a proton-transfer reaction mass spectrometer.

13) The apparatus of claim 1 further comprising a means for generating ions in communication with said entry element.

14) The apparatus of claim 13 wherein said means for generating ions is selected from the group consisting of electrospray ionization, coldspray ionization, thermospray ionization, matrix-assisted laser desorption ionization, surface-enhanced laser desorption ionization, laser vaporization, and arc discharge.

15) The apparatus of claim 1 further comprising an internal ion funnel having at least one element having a relatively small aperture and at least one element having a relatively large aperture positioned at the exit of said drift tube

wherein the element having the small aperture is positioned adjacent to the exit of said drift tube.

16) The apparatus of claim 1 further comprising a second hourglass electrodynamic funnel also formed of at least an entry element, a center element, and an exit element, each of said elements having an aperture, wherein said entry element is aligned such that a second passageway for charged particles is formed through the aperture within said entry element, through the aperture in said center element and through the aperture in said exit element, and wherein said aperture in said center element is smaller than the aperture of said entry and said exit elements, and wherein the second hourglass electrodynamic funnel forms a separate entrance to the drift tube thereby providing a second passageway for ions generated in a relatively high pressure region at the exterior of the drift tube to a relatively low pressure region at the interior of the drift tube.

17) The apparatus of claim 16 further comprising a jet disturber placed within at least one of said hourglass electrodynamic funnels.

18) The apparatus of claim 16 wherein said apertures have a shape selected from the group consisting of circular, ellipsoidal, rectangular, and combinations thereof.

19) The apparatus of claim 16 further comprising a means for temporarily containing the flow of ions out of the aperture of at least one of said exit elements of said hourglass electrodynamic funnels.

20) The apparatus of claim 19 wherein said means is selected from the group consisting of a plurality of wires, a mesh, and a microchannel plate.

21) The apparatus of claim 16 further comprising a means for intermittently terminating the flow of ions by deflecting them using an electric field orthogonal to the ion path.

22) The apparatus of claim 21 wherein said means is selected from the group consisting of a Bradbury-Nielsen gate, two or more deflection plates, and a split lens.

23) The apparatus of claim 16 further comprising an ion analysis means in communication with an exit to said drift tube, said exit located at the opposite end of said drift tube from said electrodynamic funnel.

24) The apparatus of claim 23 wherein said ion analysis means is selected from the group consisting of a mass spectrometer, a photoelectron spectrometer, and a photodissociation spectrometer.

25) The apparatus of claim 24 wherein said mass spectrometer is selected from the group consisting of a quadrupole mass spectrometer, a time of flight mass spectrometer, and a Fourier-transform ion cyclotron resonance mass spectrometer.

26) The apparatus of claim 16 wherein said drift tube is an ion mobility spectrometer.

27) The apparatus of claim 16 wherein said drift tube is selected from the group consisting of a field asymmetric waveform ion mobility spectrometer, a selected ion flow tube, and a proton-transfer reaction mass spectrometer.

28) The apparatus of claim 16 further comprising a means for generating ions in communication with at least one of said entry elements.

29) The apparatus of claim 28 wherein said means for generating ions is selected from the group consisting of electrospray ionization, coldspray ionization, thermospray ionization, matrix-assisted laser desorption ionization, surface-enhanced laser desorption ionization, laser vaporization, and arc discharge.

30) The apparatus of claim 16 further comprising an internal ion funnel having at least one element having a relatively small aperture and at least one element having a relatively large aperture positioned at the exit of said drift tube

wherein the element having the small aperture is positioned adjacent to the exit of said drift tube.

31) An apparatus useful for gas phase analysis of ions comprising:

a. an dual entry hourglass electrodynamic funnel formed of at least two entry elements, one center element, and one exit element, each of said elements having an aperture, and wherein each of said two entry elements are aligned such that a passageway for charged particles is formed through apertures within said entry elements, through the aperture in said center element and through the aperture in said exit element, and wherein said aperture in said center element is smaller than the aperture of said entry and said exit element, and

b. a drift tube, wherein the dual source hourglass electrodynamic funnel forms the entrance to the drift tube thereby providing two separate but merging passageways for ions generated in a relatively high pressure region at the exterior of the drift tube to a relatively low pressure region at the interior of the drift tube.

32) The apparatus of claim 31 further comprising a jet disturber placed within said dual source hourglass electrodynamic funnel.

33) The apparatus of claim 31 wherein said apertures have a shape selected from the group consisting of circular, ellipsoidal, and rectangular.

34) The apparatus of claim 31 further comprising a means for temporarily containing the flow of ions out of the aperture of said exit element of said dual source hourglass electrodynamic funnel.

35) The apparatus of claim 34 wherein said means is selected from the group consisting of a plurality of wires, a mesh, and a microchannel plate.

36) The apparatus of claim 31 further comprising a means for intermittently terminating the flow of ions by deflecting them using an electric field orthogonal to the ion path.

37) The apparatus of claim 36 wherein said means is selected from the group consisting of a Bradbury-Nielsen gate, two or more deflection plates, and a split lens.

38) The apparatus of claim 31 further comprising an ion analysis means in communication with an exit to said drift tube, said exit located at the opposite end of said drift tube from said electrodynamic funnel.

39) The apparatus of claim 38 wherein said ion analysis means is selected from the group consisting of a mass spectrometer, a photoelectron spectrometer, and a photodissociation spectrometer.

40) The apparatus of claim 39 wherein said mass spectrometer is selected from the group consisting of a quadrupole mass spectrometer, a time of flight mass spectrometer, and a Fourier-transform ion cyclotron resonance mass spectrometer.

41) The apparatus of claim 31 wherein said drift tube is an ion mobility spectrometer.

42) The apparatus of claim 31 wherein said drift tube is selected from the group consisting of a field asymmetric waveform ion mobility spectrometer, a selected ion flow tube, and a proton-transfer reaction mass spectrometer.

43) The apparatus of claim 31 further comprising a means for generating ions for in communication with said entry element.

44) The apparatus of claim 43 wherein said means for generating ions is selected from the group consisting of electrospray ionization, coldspray ionization, thermospray ionization, matrix-assisted laser desorption ionization, surface-enhanced laser desorption ionization, laser vaporization, and arc discharge.

45) The apparatus of claim 31 further comprising an ion detection means wherein said ion detection means is configured to received ions exiting from said drift tube from the end of said drift tube opposite said dual source hourglass electrodynamic funnel..

46) An apparatus useful for gas phase analysis of ions comprising a drift tube having an internal ion funnel having at least one element having a relatively small aperture and at least one element having a relatively large aperture positioned at the exit of said drift tube wherein the element having the small aperture is positioned to transfer ions from inside of said drift tube out of the exit of said drift tube.

47) The apparatus of claim 46 further comprising a jet disturber placed within said internal ion funnel.

48) The apparatus of claim 46 wherein said apertures have a shape selected from the group consisting of circular, ellipsoidal, and rectangular.

49) The apparatus of claim 46 further comprising a means for temporarily containing the flow of ions out of the one element having a relatively small aperture of said internal ion funnel.

50) The apparatus of claim 49 wherein said means is selected from the group consisting of a plurality of wires, a mesh, and a microchannel plate.

51) The apparatus of claim 46 further comprising a means for intermittently terminating the flow of ions by deflecting them using an electric field orthogonal to the ion path.

52) The apparatus of claim 51 wherein said means is selected from the group consisting of a Bradbury-Nielsen gate, two or more deflection plates, and a split lens.

53) The apparatus of claim 46 further comprising an ion analysis means in communication with said exit to said drift tube.

54) The apparatus of claim 53 wherein said ion analysis means is selected from the group consisting of a mass spectrometer, a photoelectron spectrometer, and a photodissociation spectrometer.

55) The apparatus of claim 54 wherein said mass spectrometer is selected from the group consisting of a quadrupole mass spectrometer, a time of flight mass spectrometer, and a Fourier-transform ion cyclotron resonance mass spectrometer.

56) The apparatus of claim 46 wherein said drift tube is an ion mobility spectrometer.

57) The apparatus of claim 46 wherein said drift tube is selected from the group consisting of a field asymmetric waveform ion mobility spectrometer, a selected ion flow tube, and a proton-transfer reaction mass spectrometer.

58) The apparatus of claim 46 further comprising a means for generating ions for in communication with an entry to said drift tube at the opposite end of said drift tube as said internal ion funnel.

59) The apparatus of claim 58 wherein said means for generating ions is selected from the group consisting of electrospray ionization, coldspray ionization, thermospray ionization, matrix-assisted laser desorption ionization, surface-enhanced laser desorption ionization, laser vaporization, and arc discharge.

60) A method for gas phase analysis of ions comprising the steps of:

a. providing an hourglass electrodynamic funnel formed of at least an entry element, a center element, and an exit element, each of said elements having an aperture, and wherein said entry element is aligned such that a passageway for charged particles is formed through the aperture within said entry element, through the aperture in said center element, and then through the aperture in said exit element, and wherein said aperture in said center element is smaller than the aperture of said entry and said exit elements,

b. providing a drift tube, wherein the hourglass electrodynamic funnel forms the entrance to the drift tube thereby providing a passageway for ions generated in a relatively high pressure region at the exterior of the drift tube to a relatively low pressure region at the interior of the drift tube through said elements, and

c. introducing ions into said entry element.

61) The method of claim 60 further comprising the step of providing a jet disturber placed within said hourglass electrodynamic funnel.

62) The method of claim 60 wherein said apertures are provided as having a shape selected from the group consisting of circular, ellipsoidal, and rectangular.

63) The method of claim 60 further comprising providing a means for temporarily containing the flow of ions out of the aperture of said exit element of said hourglass electrodynamic funnel thereby allowing groups of ions to pass from said exit element at a known time.

64) The method of claim 63 wherein said means is selected from the group consisting of a plurality of wires, a mesh, and a microchannel plate, and intermittently applying an electrical potential to said means, thereby allowing groups of ions to pass from said exit element at a known time.

65) The method of claim 60 further comprising the step of providing a means for intermittently terminating the flow of ions by deflecting them using an electric field orthogonal to the ion path.

66) The method of claim 65 wherein said means is provided as selected from the group consisting of a Bradbury-Nielsen gate, two or more deflection plates, and a split lens.

67) The method of claim 60 further comprising the step of providing an ion analysis means in communication with an exit to said drift tube, said exit located at the opposite end of said drift tube from said electrodynamic funnel.

68) The method of claim 57 wherein said ion analysis means is selected from the group consisting of a mass spectrometer, a photoelectron spectrometer, and a photodissociation spectrometer.

69) The method of claim 68 wherein said mass spectrometer is selected from the group consisting of a quadrupole mass spectrometer, a time of flight mass spectrometer, and a Fourier-transform ion cyclotron resonance mass spectrometer.

70) The method of claim 60 wherein said drift tube is provided as an ion mobility spectrometer.

71) The method of claim 60 wherein said drift tube is selected from the group consisting of a field asymmetric waveform ion mobility spectrometer, a selected ion flow tube, and a proton-transfer reaction mass spectrometer.

72) The method of claim 60 further comprising providing a means for generating ions in communication with said entry element.

73) The method of claim 72 wherein said means for generating ions is selected from the group consisting of electrospray ionization, coldspray ionization, thermospray ionization, matrix-assisted laser desorption ionization, surface-enhanced laser desorption ionization, laser vaporization, and arc discharge.

74) The method of claim 60 further comprising the step of providing an internal ion funnel having at least one element having a relatively small aperture and at least one element having a relatively large aperture positioned at the exit of said drift tube wherein the element having the small aperture is positioned adjacent to the exit of said drift tube.

75) The method of claim 60 further comprising the steps of

a. providing a second hourglass electrodynamic funnel also formed of at least an entry element, a center element, and an exit element, each of said elements having an aperture, wherein said entry element is aligned such

that a second passageway for charged particles is formed through the aperture within said entry element, through the aperture in said center element and through the aperture in said exit element, and wherein said aperture in said center element is smaller than the aperture of said entry and said exit elements, and wherein the second hourglass electrodynamic funnel forms a separate entrance to the drift tube thereby providing a second passageway for ions generated in a relatively high pressure region at the exterior of the drift tube to a relatively low pressure region at the interior of the drift tube and

b. introducing ions through said entry element of said second electrodynamic funnel.

76) The method of claim 75 further comprising the step of providing a jet disturber placed within at least one of said hourglass electrodynamic funnels.

77) The method of claim 75 wherein said apertures have a shape selected from the group consisting of circular, ellipsoidal, rectangular, and combinations thereof.

78) The method of claim 75 further comprising the step of providing a means for temporarily containing the flow of ions out of the aperture of at least one of said exit elements of said hourglass electrodynamic funnels thereby allowing groups of ions to pass from said exit element at a known time.

79) The method of claim 78 wherein said means is selected from the group consisting of a plurality of wires, a mesh, and a microchannel plate, and intermittently applying an electrical potential to said means, thereby allowing groups of ions to pass from said exit element at a known time.

80) The method of claim 75 further comprising the step of providing a means for terminating the flow of ions by deflecting them using an electric field orthogonal to the ion path.

81) The method of claim 80 wherein said means is provided as selected from the group consisting of a Bradbury-Nielsen gate, two or more deflection plates, and a split lens.

82) The method of claim 75 further comprising the step of providing an ion analysis means in communication with an exit to said drift tube, said exit located at the opposite end of said drift tube from said electrodynamic funnel.

83) The method of claim 82 wherein said ion analysis means is selected from the group consisting of a mass spectrometer, a photoelectron spectrometer, and a photodissociation spectrometer.

84) The method of claim 83 wherein said mass spectrometer is provided as selected from the group consisting of a quadrupole mass spectrometer, a time of flight mass spectrometer, and a Fourier-transform ion cyclotron resonance mass spectrometer.

85) The method of claim 75 wherein said drift tube is provided as an ion mobility spectrometer.

86) The method of claim 75 wherein said drift tube is selected from the group consisting of a field asymmetric waveform ion mobility spectrometer, a selected ion flow tube, and a proton-transfer reaction mass spectrometer.

87) The method of claim 75 further comprising the step of providing a means for generating ions for in communication with at least one of said entry elements.

88) The method of claim 87 wherein said means for generating ions is provided as selected from the group consisting of electrospray ionization, coldspray ionization, thermospray ionization, matrix-assisted laser desorption ionization, surface-enhanced laser desorption ionization, laser vaporization, and arc discharge.

89) The method of claim 75 further comprising the step of providing an internal ion funnel having at least one element having a relatively small aperture and

at least one element having a relatively large aperture positioned at the exit of said drift tube wherein the element having the small aperture is positioned adjacent to the exit of said drift tube.

90) An method for gas phase analysis of ions comprising the steps of:

a. providing an dual entry hourglass electrodynamic funnel formed of at least two entry elements, one center element, and one exit element, each of said elements having an aperture, and wherein each of said two entry elements are aligned such that a passageway for charged particles is formed through apertures within said entry elements, through the aperture in said center element and through the aperture in said exit element, and wherein said aperture in said center element is smaller than the aperture of said entry and said exit element,

b. providing a drift tube, wherein the dual source hourglass electrodynamic funnel forms the entrance to the drift tube thereby providing two separate but merging passageways for ions generated in a relatively high pressure region at the exterior of the drift tube to a relatively low pressure region at the interior of the drift tube, and

c. introducing ions into the aperture of at least one of said entry elements.

91) The method of claim 90 further comprising the step of providing a jet disturber placed within said dual source hourglass electrodynamic funnel.

92) The method of claim 90 wherein said apertures have a shape selected from the group consisting of circular, ellipsoidal, and rectangular.

93) The method of claim 90 further comprising a means for temporarily containing the flow of ions out of the aperture of said exit element of said dual source hourglass electrodynamic funnel.

94) The method of claim 93 wherein providing said means is selected from the group consisting of a plurality of wires, a mesh, and a microchannel plate and

intermittently applying an electrical potential to said means, thereby allowing groups of ions to pass from said exit element at a known time.

95) The method of claim 90 further comprising the step of providing a means for intermittently terminating the flow of ions by deflecting them using an electric field orthogonal to the ion path.

96) The method of claim 95 wherein said means is provided as selected from the group consisting of a Bradbury-Nielsen gate, two or more deflection plates, and a split lens.

97) The method of claim 90 further comprising the step of providing an ion analysis means in communication with an exit to said drift tube, said exit located at the opposite end of said drift tube from said electrodynamic funnel.

98) The method of claim 97 wherein said ion analysis means is selected from the group consisting of a mass spectrometer, a photoelectron spectrometer, and a photodissociation spectrometer.

99) The method of claim 98 wherein said mass spectrometer is selected from the group consisting of a quadrupole mass spectrometer, a time of flight mass spectrometer, and a Fourier-transform ion cyclotron resonance mass spectrometer.

100) The method of claim 90 wherein said drift tube is an ion mobility spectrometer.

101) The method of claim 90 wherein said drift tube is selected from the group consisting of a field asymmetric waveform ion mobility spectrometer, a selected ion flow tube, and a proton-transfer reaction mass spectrometer.

102) The method of claim 90 further comprising the step of providing a means for generating ions for in communication with said entry element.

103) The method of claim 102 wherein said means for generating ions is selected from the group consisting of electrospray ionization, coldspray ionization,

thermospray ionization, matrix-assisted laser desorption ionization, surface-enhanced laser desorption ionization, laser vaporization, and arc discharge.

104) The method of claim 90 further comprising the step of providing an ion detection means wherein said ion detection means is configured to receive ions exiting from said drift tube from the end of said drift tube opposite said dual source hourglass electrodynamic funnel.

105) An method for gas phase analysis of ions comprising the steps of:

a. providing a drift tube having an internal ion funnel having at least one element having a relatively small aperture and at least one element having a relatively large aperture positioned at the exit of said drift tube and wherein the element having the small aperture is positioned to transfer ions from inside of said drift tube out of the exit of said drift tube, and

b. providing ions into an entry to said drift tube at the end opposite to said ion funnel.

106) The method of claim 105 further comprising the step of providing a jet disturber placed within said internal ion funnel.

107) The method of claim 105 wherein said apertures have a shape selected from the group consisting of circular, ellipsoidal, and rectangular.

108) The method of claim 105 further comprising the step of providing a means for temporarily containing the flow of ions out of the aperture of said one element having a relatively small aperture of said internal ion funnel.

109) The method of claim 105 wherein said means is provided as selected from the group consisting of a plurality of wires, a mesh, and a microchannel plate and intermittently applying an electrical potential to said means, thereby allowing groups of ions to pass from said exit element at a known time.

110) The method of claim 105 further comprising the step of providing a means for intermittently terminating the flow of ions by deflecting them using an electric field orthogonal to the ion path.

111) The method of claim 110 wherein said means is provided as selected from the group consisting of a Bradbury-Nielsen gate, two or more deflection plates, and a split lens.

112) The method of claim 105 further comprising the step of providing an ion analysis means in communication with said exit to said drift tube.

113) The method of claim 105 wherein said ion analysis means is selected from the group consisting of a mass spectrometer, a photoelectron spectrometer, and a photodissociation spectrometer.

114) The method of claim 113 wherein said mass spectrometer is selected from the group consisting of a quadrupole mass spectrometer, a time of flight mass spectrometer, and a Fourier-transform ion cyclotron resonance mass spectrometer.

115) The method of claim 105 comprising the further step of providing said drift tube as an ion mobility spectrometer.

116) The method of claim 105 wherein said drift tube is selected from the group consisting of a field asymmetric waveform ion mobility spectrometer, a selected ion flow tube, and a proton-transfer reaction mass spectrometer.

117) The method of claim 105 further comprising the step of providing a means for generating ions for in communication with an entry to said drift tube at the opposite end of said drift tube as said internal ion funnel.

118) The method of claim 117 wherein said means for generating ions is selected from the group consisting of electrospray ionization, coldspray ionization, thermospray ionization, matrix-assisted laser desorption ionization, surface-enhanced laser desorption ionization, laser vaporization, and arc discharge.